First Measurement of $\sigma(gg \to t\bar{t})/\sigma(q\bar{q} \to t\bar{t})$ in $p\bar{p}$ Collisions at E_{CM} of 1.96 TeV

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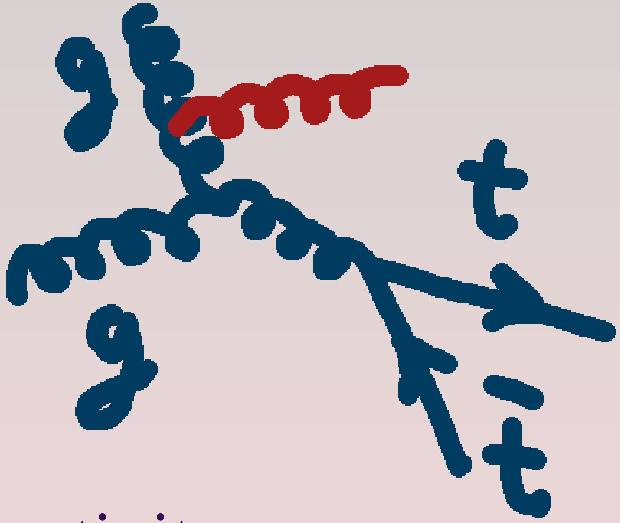
Introduction

- According to SM, in $p\bar{p}$ collisions at $\sqrt{s} \sim 2$ TeV
  - $gg \to t\bar{t}$ $\sim 15\%$
  - $q\bar{q} \to t\bar{t}$ $\sim 85\%$

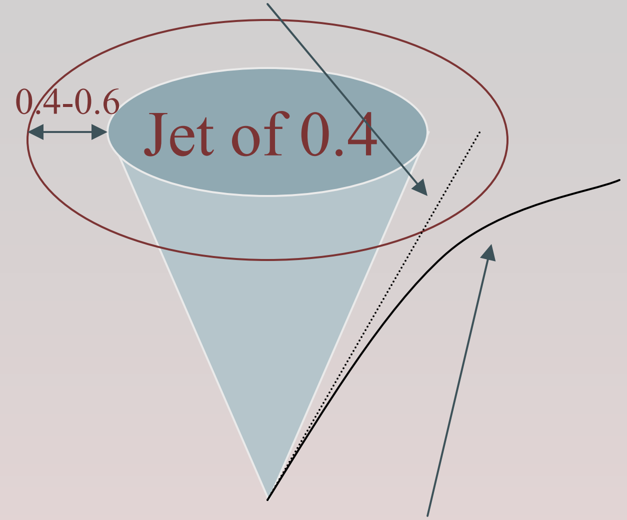


- Measure $\sigma_{(gg \to t\bar{t})} / \sigma_{(p\bar{p} \to t\bar{t})}$
  - Test of pQCD calculations
  - Non-SM mechanisms
- Processes differ in underlying activity
  - The difference comes from ISR

The Difference

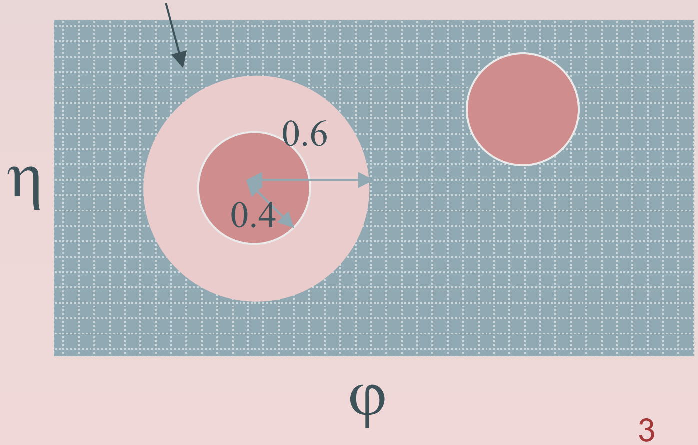
- Gluons radiate more gluons than quarks do
  - More charged particles in gg channel
- Track Multiplicity
  - Low p_T
  - $|\eta| \leq 1.1$
  - Matched to the event vertex
  - Away from jets
  - Correct for area differences

Track if no magnetic field exists



Track in magnetic field

Jet of 0.4 and its annuli



Calibration Samples

- Can not rely on the modeling of gluon radiation
- Should calibrate using data
  - W + n jet events
    - W with no jet is mainly $q\bar{q}'$
    - As jet multiplicity increases, the gluon-content increases
  - Dijet events
    - Gluon-content decreases as the leading jet E_T increases

Jet in W+ n jet categories:

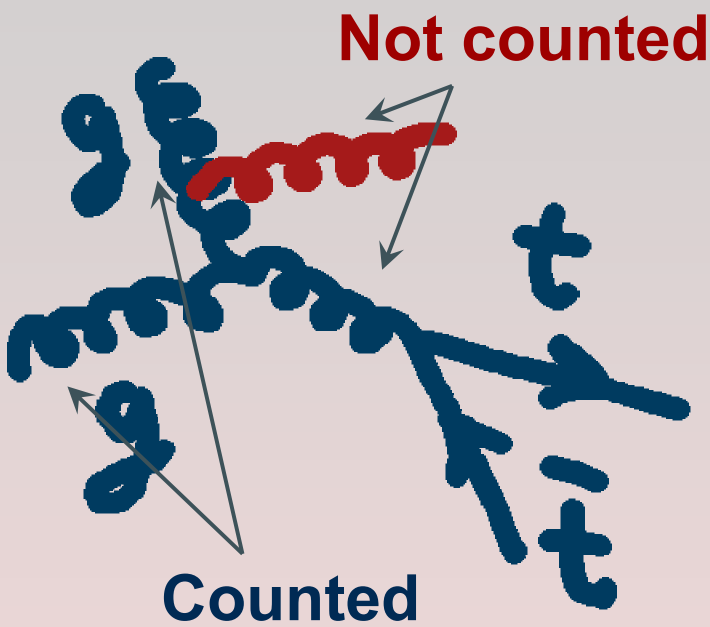
- $E_T \geq 15$
- $|\eta| \leq 2$

Leading jet in dijet categories:

- starting from 80 GeV
- bins of 20 GeV
- up to 220 GeV or more

Correlation of $<N_{trk}>$ and $<N_g>$ ...

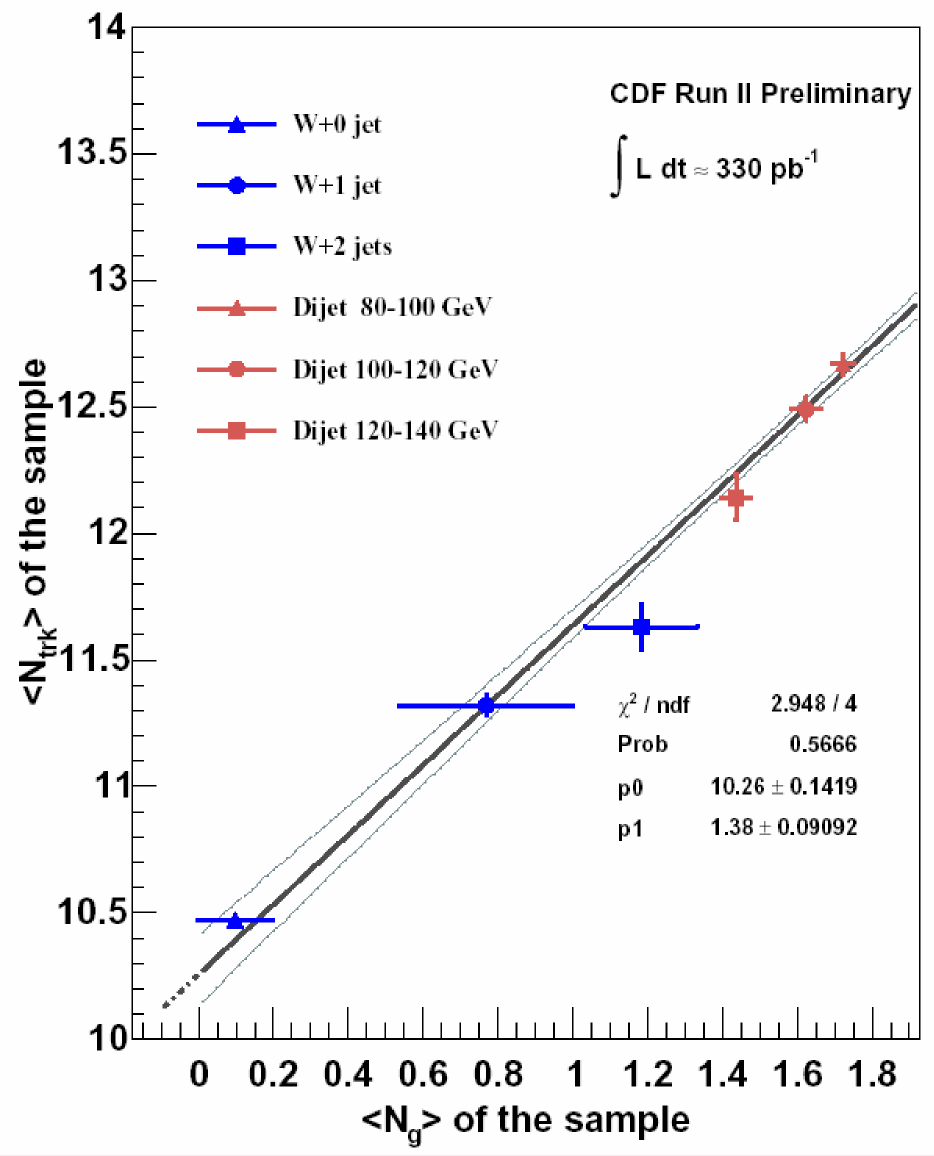
- Count the number of gluons which are part of the Martix Element
- Add the number for all the MC events
- Divide by the total number of MC events



$$\frac{\sum_{\text{events}} \text{number of gluons in the initial and final state of the process}}{\text{Total number of events}}$$

...Correlation of $<N_{trk}>$ and $<N_g>$ ...

Sample	MC $<N_g>$	Data $<N_{trk}>$
W+0 jet	0.10 ±0.10	10.47±0.01
W+1 jet	0.77 ±0.23	11.32 ±0.04
W+2 jets	1.18 ±0.15	11.63 ±0.09
80-100 GeV	1.72 ±0.03	12.67 ±0.04
100-120 GeV	1.62 ±0.04	12.49 ±0.05
120-140 GeV	1.44 ±0.04	12.14 ±0.09



Using the fit to find $<N_g>$ for $<N_{trk}>$ of other calibration samples

Sample	MC prediction	Fit result
140-160 GeV	1.26 ±0.04	1.19 ±0.04
160-180 GeV	1.13 ±0.04	1.06 ±0.05
180-200 GeV	0.99 ±0.07	0.93 ±0.05
200-220 GeV	0.92 ±0.10	0.75 ±0.07
220+ GeV	0.67 ±0.10	0.60 ±0.07

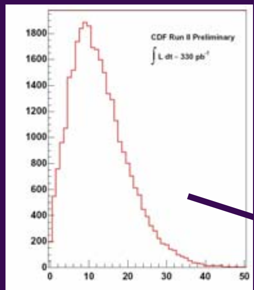
Measuring <Ng> in Calibration Samples

- Define and parameterize two distributions representing no-gluon and gluon-rich samples
  - F_q, W+0 jet which is almost purely qq→W
  - F_g, dijet sample with leading jet E_T of 80-100 GeV after we subtract the qq component from it, here we use PYTHIA dijet Monte Carlo calculations, an average of 2.37 gluons
- Use the normalized parameterization of the two distributions in a fit to the low p_T track multiplicity distribution in any other sample

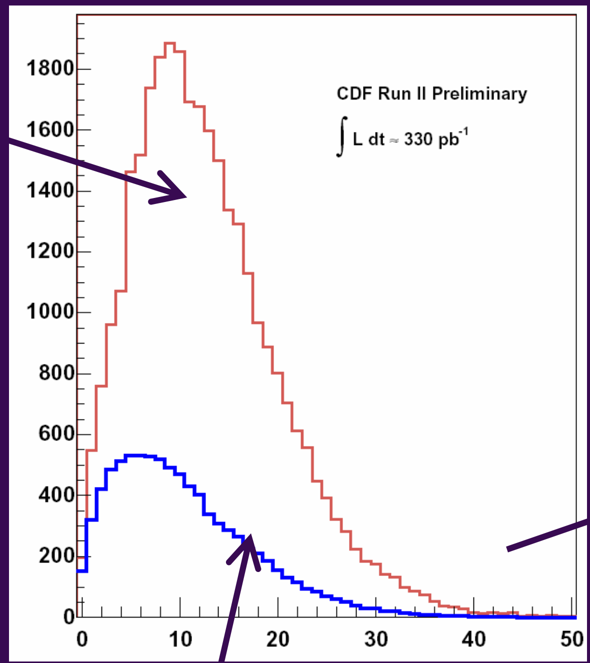
$$N[f_{glu-rich} F_g^{norm} + (1 - f_{glu-rich}) F_q^{norm}]$$

- $<N_g>^{measured} = 2.37 * f_{glu\text{-}rich}$

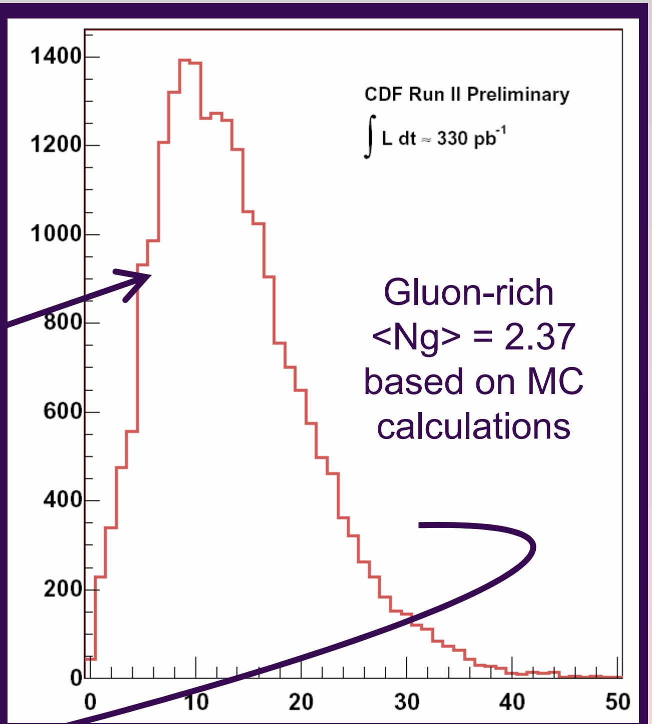
No-Gluon & Gluon-Rich Distribution



DATA
dijet 80-100 GeV
Based on MC
27% qq → qq
<Ng> = 2.37
for the rest

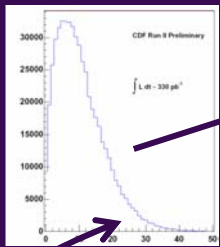


Subtract



Gluon-rich
<Ng> = 2.37
based on MC
calculations

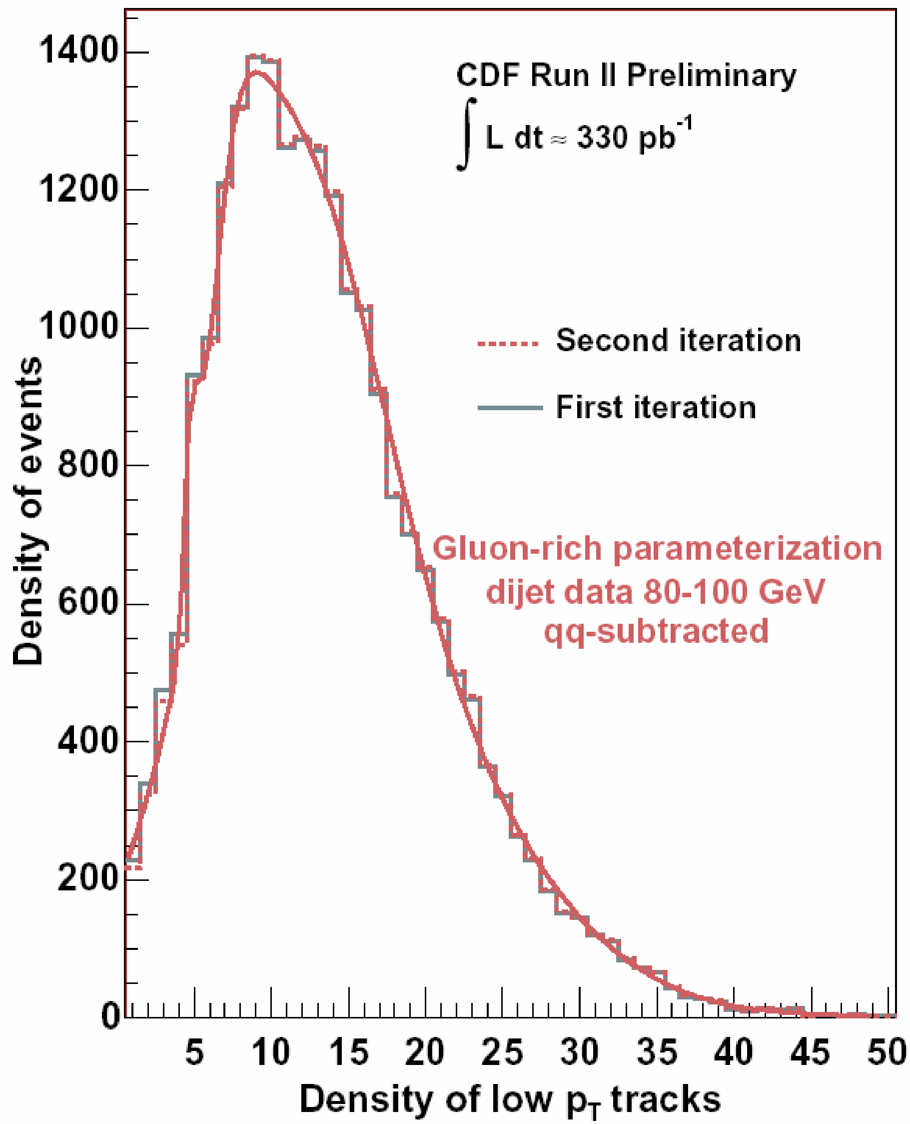
DATA
W+0 jet
Similar to
qq → qq

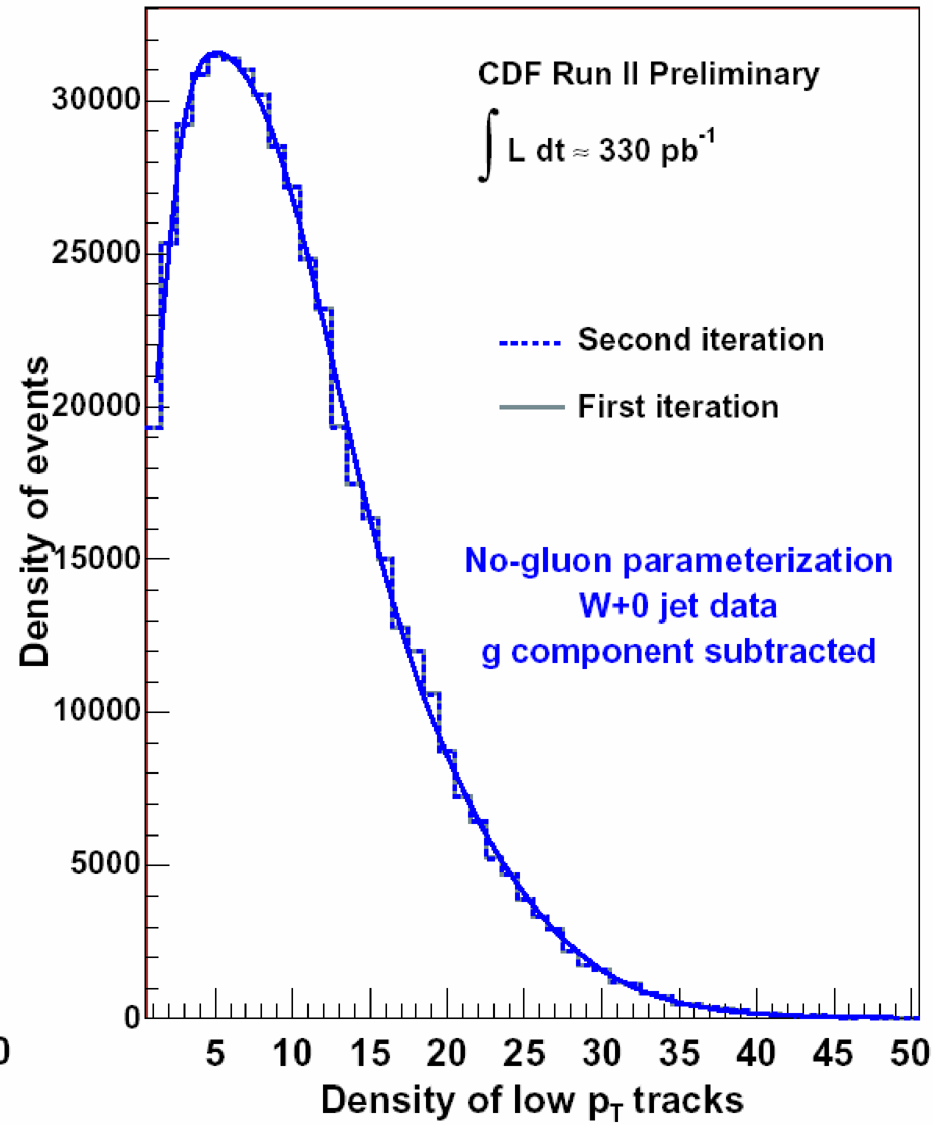


...rmalized to dijet
80-100 GeV
Scaled by 0.27 to
represent qq → qq

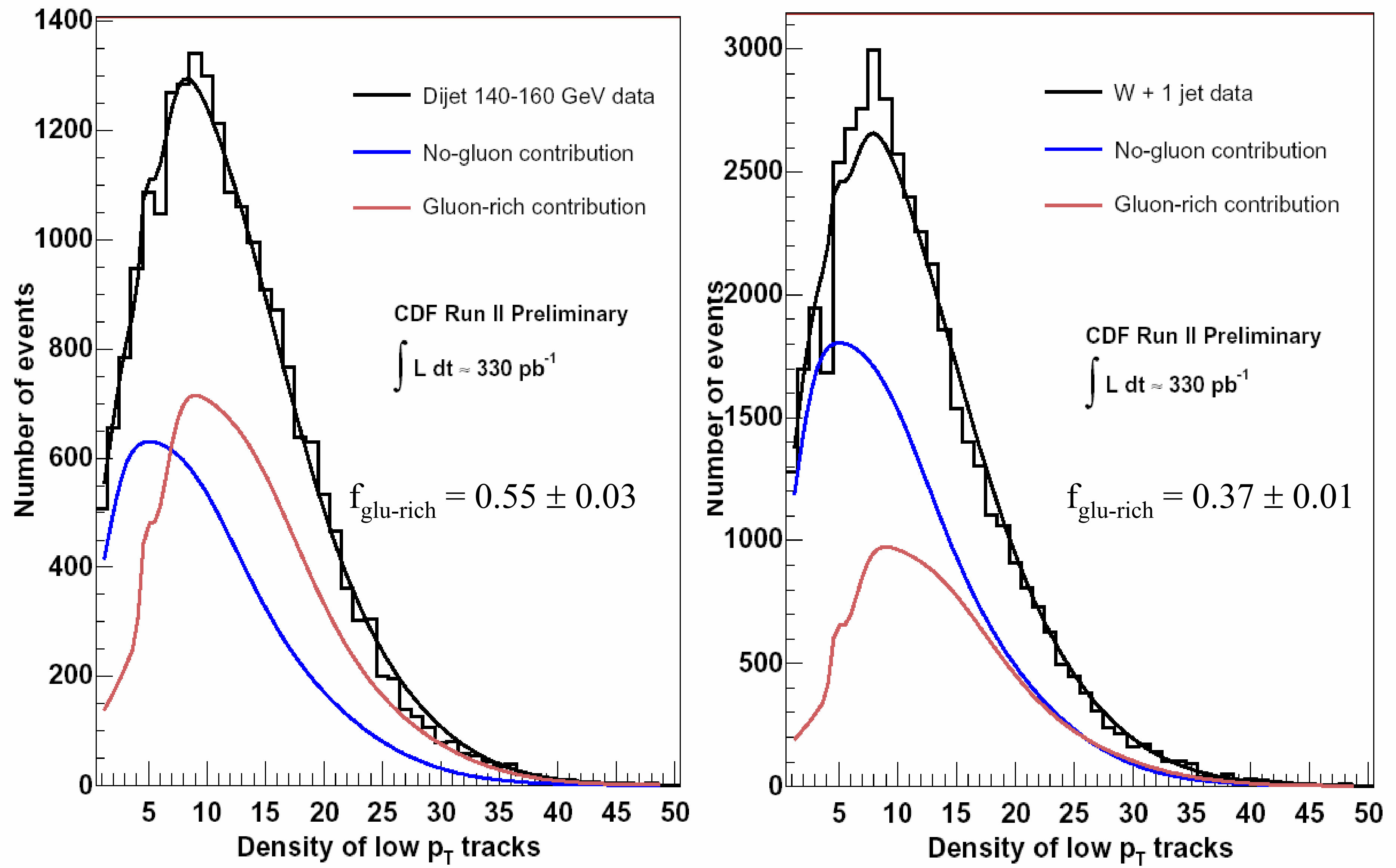
Iterate to subtract gluon contributions
from W+0 jet data distribution

Parameterizations





Two sample fits



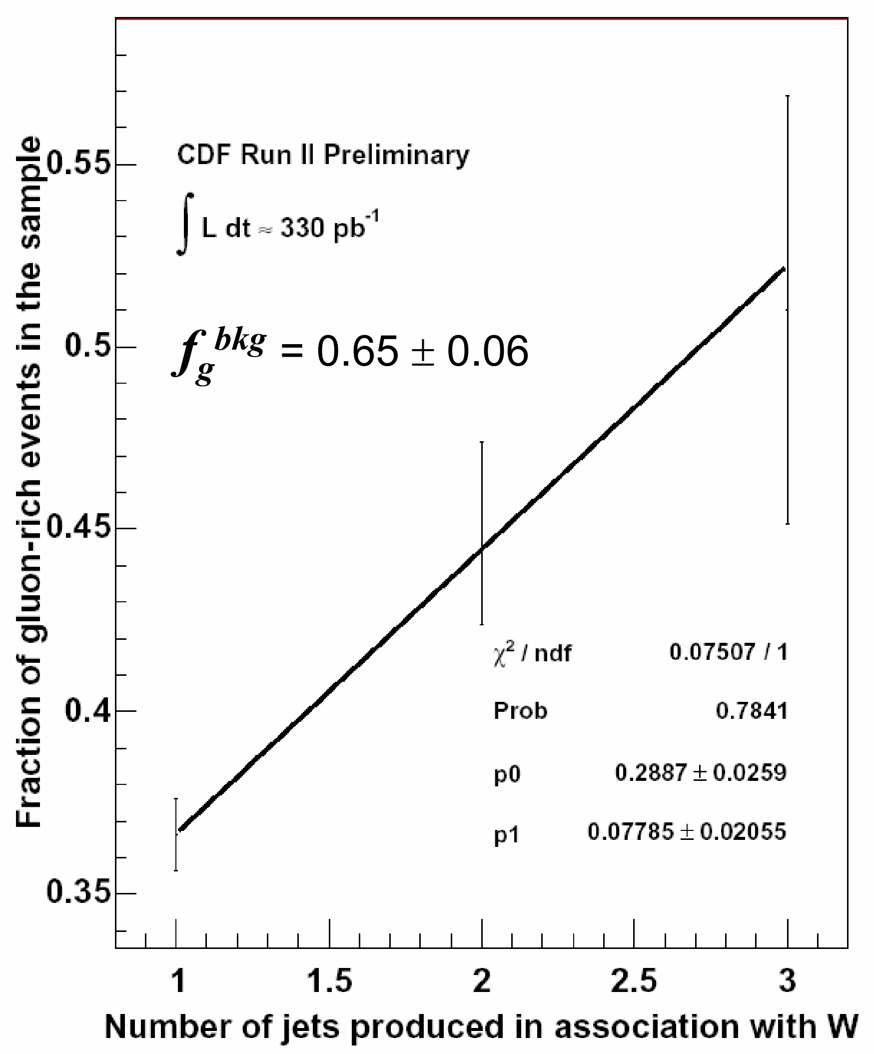
Sample	$\langle N_g \rangle$ from fit $2.37\,f_g$	MC $\langle N_g \rangle$
W+1 jet	0.87 ± 0.03	0.92 ± 0.08
W+2 jet	1.06 ± 0.05	1.33 ± 0.15
100-120 GeV	1.61 ± 0.03	1.62 ± 0.02
120-140 GeV	1.49 ± 0.05	1.44 ± 0.04
140-160 GeV	1.30 ± 0.03	1.26 ± 0.04
160-180 GeV	1.18 ± 0.03	1.14 ± 0.04
180-200 GeV	1.06 ± 0.05	0.99 ± 0.07
200-220 GeV	0.95 ± 0.07	0.92 ± 0.10
220+ GeV	0.76 ± 0.07	0.67 ± 0.10

Fraction of gg → ttbar events

- f_g in W+≥4 jet tagged sample can be written as

$$f_g = f_{bkg} f_g^{bkg} + (1 - f_{bkg}) f_g^{tt}$$

where f_{bkg} is fraction of background in the sample, f_g^{bkg} is the gluon rich fraction in the background and f_g^{tt} is the fraction of gluon rich events in the ttbar signal



Systematic uncertainties

Type	Source	f_g^{bkg}	f_g	$A_{gg\to tt} / A_{qq\to tt}$
Quark-gluon composition	$qq \to qq$ fraction	±0.02	± 0.02	-
	K_T	$+0.00$ -0.02	±0.02	-
	QCD bkg composition	$+0.00$ -0.02	$+0.00$ -0.01	-
Track counting	Low ET cut	$+0.02$ -0.00	$+0.00$ -0.03	-
	Trk/jet correction	$+0.00$ -0.01	$+0.03$ -0.02	-
	Z vertex matching	-	-	-
Others	true pseudoexperiments comparison	±0.05		
	f_g^{bkg} estimate method	±0.13	-	-
	PDF and MC	-	-	±0.04
Total		±0.14	±0.04	±0.04

Result

- Using a background fraction of (13 ± 3)%, we get

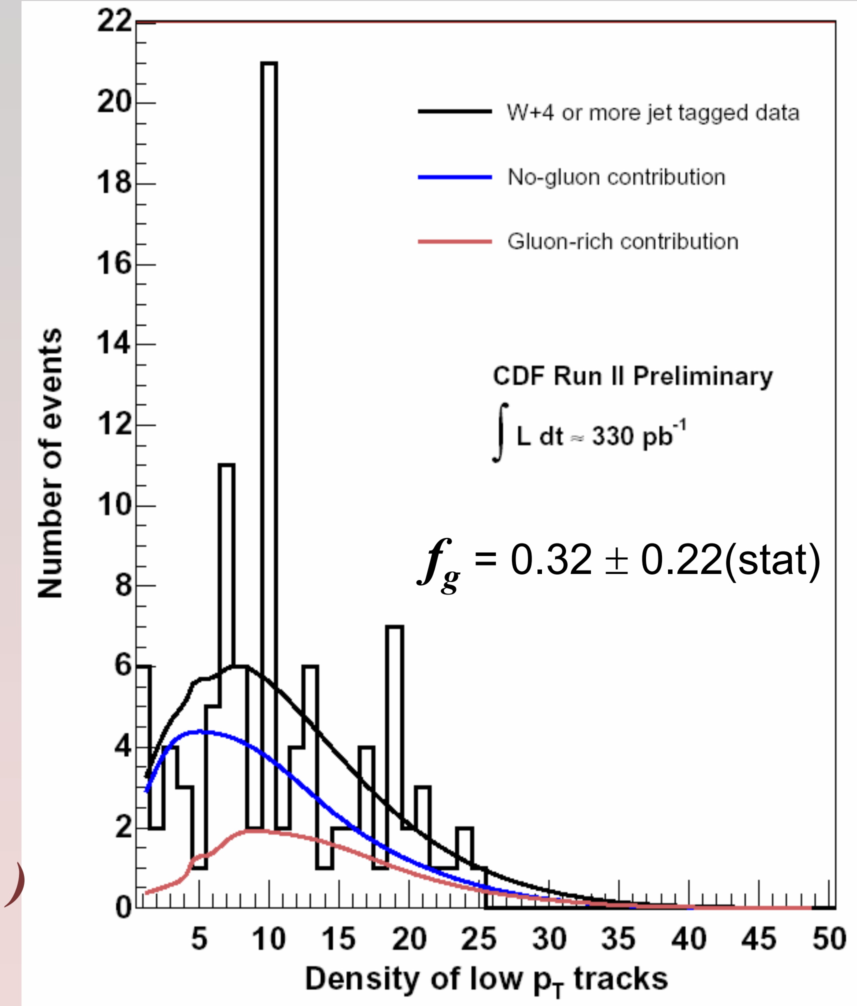
CDF Preliminary

$$f_g^{tt} = 0.28 \pm 0.25(stat) \pm 0.10(syst)$$

- And using a ttbar acceptance of 0.06 ± 0.01 and 0.05 ± 0.01 for gg fusion and qqbar respectively, we find

CDF Preliminary

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = 0.25 \pm 0.24(stat) \pm 0.10(syst)$$



Summary

- Using about 330 pb^{-1} data collected at CDF and a data-driven method, we show
  - There exists a clear correlation between the $<N_g>$ and $<N_{trk}>$
  - $<N_g>$ in a sample can be determined using low p_T track multiplicity distribution of the sample
  - The fit results are in good agreement with MC predictions
  - The first measurement of

$$\frac{\sigma(gg \to t\bar{t})}{\sigma(p\bar{p} \to t\bar{t})} = 0.25 \pm 0.24(stat) \pm 0.10(syst)$$

CDF Preliminary